adapted to students of various grades in various subjects. They may be useful for giving suggestions to teachers who are themselves poorly prepared, but are not of the character to be placed in the hands of the beginning pupil. The pupil, to again quote the sentiment of the author, should be taught without books.

Treated, however, as a book for the instruction of teachers, this work possesses many meritorious features, among which we may mention:

1. It outlines work that can be accomplished without the aid of a compound microscope. This is highly important, because many schools cannot be equipped with compound microscopes, and what is a better reason, because a pedagogical one, it will prevent pupils becoming familiar with the compound microscope before they have exhausted the possibilities of the simple one. Botanical perspective cannot be attained by looking down the tube of a compound microscope alone, and the failure to learn how to use the unaided eye or a simple lens has been responsible for some of the lack of perspective in the rising generation of botanists.

2. It emphasizes the ecological side of botany, which is destined to be the next ruling feature of elementary botanical instruction.

3. Its list of required laboratory books for the teacher is short but excellent, and emphasizes the feature last named in such books as those of Kerner and Selina Gaye, and rigidly excludes manuals and other works on systematic botany which belong to a later stage in the evolution of botanical students.

Besides the general criticism given above, which falls on this book only as one of a special class, there are features peculiar to itself that could be improved. For example, it combines, among many suggestions suitable to the age of the pupils for which the work is intended, some that seem infantile and others that savor of pedantry or at least belong to children of a larger growth. Such expressions as 'strophiole,' 'phytomer,' 'reclinate præfoliation' and 'indeterminate anthotaxy,' might well be deferred to a later stage of instruction, if introduced at all. Then the work gives a more fragmentary treatment of the spore-producing plants than would be expected from a specialist in cryptogamic botany, tending, as was the case with Dr. Gray's text-book, on which this is quite closely patterned, to create the impression that all plants produce flowers or at least all that are worth considering. Besides leaving out a half of the plant world, and an important half at that, this plan hides away from the student the great principle of evolution of plant life which would be impressed upon him unconsciously were the study to commence with lower forms or at least give them a fair amount of attention. It is amazing how much knowledge of these lower plants can be gained by means of a simple magnifier, and it is unfortunate, to say the least, to prevent the student, however young, from getting a well-rounded conception of the whole subject. There are some few obsolete expressions in the book like 'stomata or breathing pores' and occasional typographical slips that it is always difficult to avoid in a first edition. On the whole, the merits of the work are much greater than its demerits, and if used by teachers alone, and not by students, it is probably as good or better than most the books of its type.

L. M. UNDERWOOD.

Essai critique sur l'hypothèse des atomes dans la science contemporaine. ARTHUR HANNEQUIN. Annales de l'Université de Lyon. Tome Septième. Paris, G. Masson. 1895. Pp. 419.

This is an interesting and important book of its kind, but it is also a kind of book which to many physicists will need justification. It is a serious attempt to form a philosophy of atomism, and as such will be found to contain too much physics to please most metaphysicians and too much metaphysics to please physicists. That each party in the case may take his own, the book is frankly divided into two parts, the first having to do with atomic theory as actually found in science, and the second with the metaphysics of this theory. But it would be too much to hope that the physics and the metaphysics of atomism had actually been disentangled and separated. Whatever the metaphysician may do the wise physicist will read the whole book if he wishes to get M. Hannequin's complete message.

The book is written in a charming style, picturesque without loss of dignity and vivacious without flippancy. The discussion is at once so orderly and so complete as to give a high impression of unity and elegance. To one interested in the subject the book will prove easy and delightful reading. While we have in English many books upon parts of the field and many special investigations concerning molecular action we have yet no general work like this upon the foundations of atomism. Stallo's Modern Physics comes nearest to it and, although elementary in character and limited in scope, deserves to be better known than it is.

It is easy to see that the main interest of the author is philosophy and yet he shows everywhere wide and thorough reading in the history of atomistics and also in modern physics and mathematics. But with competent knowledge his perspective is often false. Leibnitz, though not better known, seems distinctly nearer to him than Maxwell, and he does not scruple to put down Cantor with a quotation from Descartes. Indeed the book is not only scholarly, but distinctly scholastic. This is perhaps the reason why the author takes everywhere a hard and fast view of science as a fixed body of knowledge instead of the growing, elastic, tentative thing that it really is. Having proved that the universe cannot be explained by the atom of Greek philosophy, a hard, round, indivisible solid, without parts or qualities, he fails to do justice to, although he shows a full consciousness of, modern atomistic speculation. M. Hannequin's statement on page 225, and everywhere implied throughout the book, that "the rigorous unity and the perfect simplicity of an explanation are the highest guarantees of its truth," should be limited to pure science. For experimental science this is an early and naïve view. The universe, and every part of it, is infinitely complex and diverse, and any view that makes it small and plain is the view of innocence, or of one who cares more for method than for matter.

The argument of the book runs in part as follows:

As the mind knows completely only what it creates—knows of things only what it projects into them—so science is rigorous and exact in such measure as it is a creation of the mind. Science takes its rise in the human need of rendering intelligible that which falls beneath the intuition of the senses. Number the mind has created and so knows completely, but extension and direction the mind cannot know directly. It can know these categories only by breaking them up into equal parts and counting them, that is, by *measuring*.

The first step in progress is the reduction of the physics of fact and phenomenon to the physics of law, which in its more generalized form becomes the physics of succession and change. The fundamental change—change of place or motion—turns one side toward fact and the other toward a rigorous mathematic, in terms of which the laws of succession and change are expressed. Thus science becomes universal in motion only as it breaks up its continuity by number. So we triumph over continuity by dividing it into units of time and mass, units small enough to measure any time and any space. These units, *the differentials of mathematics*, are the atoms of pure science—of geometry, of algebra, of kinematics, etc. Thus atomism is a necessary hypothesis growing out of the nature of knowledge.

So far we follow our author mainly with satisfaction, even in his long argument to prove that number and measurement are fundamental in geometry. A straight line is the shortest distance between two points; found shortest by measuring. Other definitions of a straight line he endeavors to reduce to the same notion. But all lines are made up of straight lines, and all figures are bounded by lines, so that all figures bear about with them quantitative relations. To arrive at this conclusion he ignores projective geometry, and discredits transcendental geometry by arguments which are familiar.

But the atom in pure science is a concept, the object of a definition. We must not project it into the real world. So how about atomism in nature? This is, of course, the main theme of the book, and is pursued through the various fields of chemistry, mineralogy, optics, electricity, etc., with intelligence and thoroughness. Mainly he will carry the great body of physicists with him. Sometimes he will part company with them; as when he insists that

the atom must have volume if it has mass, and that equal elementary masses imply equal volumes; when he attempts to disprove the possibility of a vortex atom in a homegeneous fluid; when he tries to prove the conception of atoms as centers of force inconsistent with the idea of mass; and in many details of his argument.

With greater success he exhibits the inconsistency and incompleteness of molecular theory in chemistry; shows the inadequacy of the hypothesis of a single ether or a multitude of ethers to explain action at a distance; of the hypothesis—'that scandal of atomistics'—of molecular atmospheres to explain attraction and repulsion; and, in general, of any hypothesis of an indivisible element to explain elasticity and other properties of matter. He compels us to see that our analysis only draws out of the atom what we have put into it; that, indeed, the atom of modern physics is a little world, almost organized, upon which are assembled all the properties and dynamic relations which it was to have been their mission to explain.

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SCIENTIFIC JOURNALS.

THE AMERICAN JOURNAL OF SCIENCE.

The leading article of the May number is a biographical paper about the late Professor Hubert A. Newton, by J. W. Gibbs. It presents a brief account of his life and estimate of his personal character, and besides gives an extended and thorough summary of his contributions to astronomical science. This paper was read before the National Academy of Sciences at the recent meeting in Washington.

A. G. Webster discusses a method of producing constant angular velocity in cases where a considerable amount of power is needed, as in driving a large telescope or siderostat. It is based upon the use of a tuning fork which interrupts an intermittent current and thus regulates an electric motor. Some experiments show that the method is a practical one up to more than one and a-half horse power. The same author also discusses a method for rapidly breaking powerful electrical currents. The end is accomplished by making the break under water while the mercury surface employed is kept clean by being continuously elevated by means of an aspirated pump. By this means the jet is kept cool and presents a continually fresh surface of mercury, this being washed by the flowing water. The apparatus was found satisfactory in a current of twelve mean ampéres carried on for the course of an hour.

John Trowbridge, following out the line of discussion involved in the paper in the April number, discusses the 'Electrical Conductivity of the Ether.' By the method employed the author thinks he obtains an estimate of the energy required to produce the Röntgen rays and also a measure of resistance of sparks in air and different media. He closes thus: "It shows conclusively that the discharge in a Crookes tube at the instant when the Röntgen rays are being emitted most intensely is an oscillatory discharge. In popular language it can be maintained that a discharge of lightning a mile long under certain conditions encounters no more resistance during its oscillations than one of a foot in length. In other words, Ohm's law does not hold for electric sparks in air or gases. Disruptive discharges in gases and in air appear to be of the nature of voltaic arcs. Each oscillation can be considered as forming an arc. It is well known that a minute spark precedes the formation of the voltaic arc in air. The medium is first broken down and then the arc follows. I believe that this process occurs also in a vacuum and that absolute contact is not necessary to start the arc. My experiments lead me to conclude that under very high electrical stress the ether breaks down and becomes a good conductor."

T. W. Richards and John Trowbridge discuss the effect of great current strength on the conductivity of electrolytes. Experiments were made with copper sulphate and zinc sulphate, and the conclusion is reached that the conductivity is not essentially affected by great changes in the strength of the current.

H. S. Williams has a paper on the Southern Devonian formations, especially in southern Virginia, Tennessee and Kentucky, where he has recently carried on personal observations. He shows the remarkable contrast which exists between the formation as known in New York State and that as developed in the South, where